



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Emotional recognition in ASD from voices and faces

Citation for published version:

Stewart, ME, McAdam, C, Ota, M, Peppe, S & Cleland, J 2013, 'Emotional recognition in ASD from voices and faces', *Autism*, vol. 17, no. 1, pp. 6-14. <https://doi.org/10.1177/1362361311424572>

Digital Object Identifier (DOI):

[10.1177/1362361311424572](https://doi.org/10.1177/1362361311424572)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Autism

Publisher Rights Statement:

© The authors. This is an author's accepted manuscript of the following article: Stewart, M. E., McAdam, C., Ota, M., Peppe, S. & Cleland, J. (2013), "Emotional recognition in ASD from voices and faces", in *Autism*. 17, 1, p. 6-14. The final publication is available at <http://dx.doi.org/10.1177/1362361311424572>

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Emotional recognition in Autism Spectrum Conditions from voices and faces

The present study reports on a new vocal emotion recognition task and assesses whether people with Autism Spectrum Conditions (ASC) perform differently from typically developed individuals on tests of emotional identification from both the face and the voice. The new test of vocal emotion contained trials in which the vocal emotion of the sentence were congruent, incongruent, or neutral with respect to the semantic content. We also included a condition in which there was no semantic content (a ‘mmm’ was uttered using an emotional tone). Performance was compared between eleven adults with ASC and fourteen typically developed adults. Identification of emotion from sentences in which the vocal emotion and the meaning of sentence were congruent was similar in persons with ASC and a typically developed comparison group. However, the comparison group was more accurate at identifying the emotion in the voice from incongruent and neutral trials, and also from trials with no semantic content. The results of the vocal emotion task were correlated with performance on a face emotion recognition task. Individuals with ASC used semantics as a strategy to decode emotion from sentences, whereas typically developed individuals tended to process emotional information in a more ‘automatic’ manner.

Keywords: Emotion, Autism Spectrum Conditions, prosody, vocal emotion

Individuals with Autism Spectrum Conditions (ASC) display divergent behaviours in processing and understanding emotional states in others. This has been demonstrated in emotion identification either from the face or the voice (Balconi and Carrera, 2007, Boucher et al., 1998, Hobson et al., 1989, Humphreys et al., 2007, Loveland et al., 1995, Peppé et al., 2007, Van Lancker et al., 1989). Problems in identifying vocal emotion have been reported in both children and adults with ASC. For instance, children with autism have difficulty matching vocally expressed affect to static facial expressions or to emotion words (Boucher et al., 1998, Hobson et al., 1989, Van Lancker et al., 1989); and vocal emotions to dynamic images such as videos of faces (Loveland et al., 1995). Peppé and colleagues found that children with high functioning autism were less accurate at identifying emotion in a voice (Peppé et al., 2007). In their task, the children heard a word such as ‘salad’ said either in a happy or sad voice, which they had to match with a happy or a sad face shown on a computer screen. Paul and colleagues similarly found identification of affect from the voice to be impaired in children with ASC (Paul et al., 2005). In their study the children heard a sentence and were asked to indicate a picture which represented the emotion being portrayed in the voice. For instance, the children might hear “You’re going to be late for school” said in a calm or an excited voice, and then see a picture of a lady looking calm and a picture of a lady feeling excited to choose from.

Similar differences have been found in adults with HFA/Asperger Syndrome (AS) (Golan et al., 2006, Golan et al., 2007, Rutherford et al., 2002). For example, Rutherford and colleagues (Rutherford et al., 2002) played recorded segments of dialogue from dramatic audio books (e.g., ‘No, honestly I do’), from which participants were asked to identify the speaker’s mental attitude or emotion from a choice of two (e.g., ‘Earnest’ vs. ‘Alarmed’). The ASC group were less accurate at identifying the emotion in the voice than control groups.

Such differences are not only found in emotion identification based on vocal information but also on facial expressions. Golan et al. (2006) used the Cambridge mindreading face-voice battery, in which participants were played either a short neutral sentence spoken by an actor in a particular emotional tone, or a short clip of actors portraying a facial emotion. Participants were instructed to choose one response from four which best described the speaker's mental state. The results showed that, compared to typically developed general population controls, adults with Asperger Syndrome (AS) were less accurate at identifying emotion from both voices and faces. Kleinman and colleagues showed a similar result in high functioning adults with ASC using the Mental State Voices Task (Kleinman et al., 2001). A neutral sentence was said in one of the six 'basic' emotions (happy, sad, angry, afraid, surprised, and disgusted) (Ekman, 1993) and in six more complex emotions (arrogant, guilty, calm, anxious, bored, and interested). Participants were also given the Reading the Mind in the Eyes task (Baron-Cohen et al., 2001). Adults with ASC were impaired compared to typically developed controls on both tasks. Other studies also show that both adults and children with ASC tend to be less accurate at identifying emotions from faces (Balconi and Carrera, 2007, Humphreys et al., 2007). The difficulty exhibited by individuals with ASC increases as the emotion to be detected becomes more complex than the 'basic' categories of happiness, sadness, fear, anger, surprise and disgust (Capps et al., 1992).

However, individuals with ASC do not consistently diverge from neurotypicals in their decoding of emotions. In Grossman et al. (2000), children and adolescents with AS did not differ from controls in their ability to recognize facial emotions when the faces were paired with matching words (e.g., a happy face with the word HAPPY), even though they did so when they were shown mismatching words (e.g., a happy face with the word AFRAID), which typically led them to a response based on the word rather than the face. Similarly, Lindner and Rosén (2006)

found that children and adolescents with AS did not perform worse than their typically developing counterparts in deciding the emotion expressed in an acted out scene when the emotion was expressed in the semantic content of the actor's verbalization. When this verbal semantic cue was absent, the AS participants encountered difficulties in identifying the intended emotion. These findings indicate that individuals with ASC rely on linguistic semantics, where their emotion decoding ability is spared.

The main purpose of this study was to test whether a similar compensatory strategy could be observed in emotion detection in speech stimuli only (i.e., without any accompanying facial expression or visual context). We expect individuals with ASC to show more variation than typically-developed individuals in their emotional interpretation of auditory speech samples depending on how much information on emotion is directly encoded in the linguistic material (e.g., words that denote a particular emotional state). To test this, we developed measures of emotional interpretation using sentences with different degrees of congruency between prosodic and semantic information, and also hummed utterances ('mmm') devoid of semantic content. Each sentence or "mmm" was said in a different emotion: happy, anger, fear, surprise or disgust. The intended emotion in the voice was in some trials also discernable from the semantic content of the sentence (e.g., "Stop that at once!" said in an angry voice; the voice and the meaning of the sentence were congruent), but contradictory to the semantic implications in others (e.g., "Stop that at once!" said in a happy voice; the voice and the meaning of the sentence were incongruent). We predicted a difference between individuals with ASC and typically developed participants in the latter ('incongruent') condition, but a reduced effect or no difference in the former ('congruent') condition, where the meaning of the sentence can be used to identify the emotion expressed. We also predicted a difference between the two groups in the 'mmm'

condition, as the only source of emotional information in these materials was the prosody. In this condition, individuals with ASC would not be able to use a semantic strategy to interpret the emotional intonation.

A second goal of the study was to examine the connection between vocal and facial recognition of emotion. If the emotional processing difficulties in ASC are caused by a deficit in similar cognitive processes, then emotion interpretations of different sources, such as faces and vocalisation, will be subjected to the same underlying problem. We would therefore expect to see a close connection between these behaviours (i.e., understanding of emotions in faces and in vocalisation) in each ASC individual as has been found in previous studies (Golan et al., 2006, Kleinman et al., 2001). To test this, we also administered a task where participants were required to identify emotion from a face. The prediction was that for individuals with ASC, there would be a correlation between scores in the facial emotion recognition task and the incongruent condition of the vocal task.

Method

Participants

The participants were 11 individuals with ASC and 14 controls between 17 and 39 years old. Participants with ASC were recruited from a “One-Stop Shop” facility for individuals with Asperger Syndrome and high functioning autism. The facility provides free social opportunities, one-to-one advice and support in a range of areas including outreach and housing. Only those participants who had been previously diagnosed by a qualified clinician meeting the criteria of

DSM-IV (Diagnostic and Statistical Manual of Mental Disorders Edition IV) were included in the study. Comparison participants were recruited from the general population.

Measures

Tests of Emotional Prosody

The participants listened to recorded stimuli played on a computer over headphones through the platform of E-Prime. The stimuli were recorded by a professional female actor. The actor had a standard Scottish accent and was approximately the same age as the participants. There were three tests of prosody assessing the impact of semantic/lexical information and prosodic factors. The stimuli were said in one of five emotions: anger; fear; happiness; surprise; and disgust. Participants were asked to "...indicate the emotion that is being portrayed in the voice" in each stimulus by selecting one of 6 numbered answer options which appeared on the screen: Anger; Fear; Happy; Surprise; Sad; Disgust. Participants selected the correct answer using the corresponding number on the keyboard. The answer options were randomised to ensure that reaction time was not influenced by the number position of the correct answer.

Sentences

Participants listened to 120 sentences the meaning of which was either emotional or neutral. Emotional sentence were sentences that implied an emotional state, for example, "Stop that at once!" implies an angry emotional state. Sentences were tested in a pilot study where participants were asked to identify the emotional state in the sentence. Sentences in which the emotion was identified at less than 75% accuracy were discarded. Eight sentences were chosen for each of the 5 emotions being tested (happiness, fear, surprise, anger and disgust). These sentences were said with either emotionally congruent or emotionally incongruent prosody. For

example, “Stop that at once!” said with prosody implying anger would be congruent, but incongruent if it was said with prosody implying happiness. Neutral sentences which did not imply any emotional state were also included, for example, “He drank a cup of tea”. Eight neutral sentences were chosen and these 8 sentences were each heard portraying each of the five emotions. In total, each participant heard 40 congruent, 40 incongruent and 40 neutral sentences.

“mms”

To test the ability to identify vocally expressed emotion without lexical information, participants listened to vocalisations of ‘mmm’ uttered in each of the five emotions. There were a total of 25 trials, and the answer selection process was the same as that for the sentences and words. Participants were given 5 practice trials before the real test.

Facial emotion recognition

For the facial emotion recognition task, 8 faces were chosen for each of the 6 basic emotions from the JAFFE database (Lyons et al., 1999). Participants viewed the faces on the computer screen and were asked to choose which emotion the face was portraying from a list of the 6 basic emotions that appeared alongside the picture.

Procedure

Participants were asked to complete the tests in a set order. Participants completed the Millhill vocabulary test first, followed by tests of emotional prosody, and the facial emotion recognition test. Participants could take regular breaks, all the testing was completed in one session.

Results

The groups were matched on verbal IQ ($t = 1.547$, $df = 23$, n.s.), which was measured using the multiple choice form of the Mill Hill Vocabulary Scale (Raven et al., 1998), and on age. Gender ratios in the two groups were similar. Four of the group with ASC were female and seven were male, six of the typically developed group were female and eight were male.

Accuracy and reaction time for the voice tasks, mean performance on the faces, age and verbal ability tasks are shown in Table 1. In the voice task, accuracy was much higher for both groups when the emotion in the voice was congruent with the meaning of the sentence. A repeated measures analysis of variance was carried out to determine the effects of group and condition in the sentences task. There was a main effect of congruency ($F_{2,22} = 84.71$, $p < 0.001$), a main effect of group ($F_{1,23} = 29.30$, $p < 0.001$), and an interaction between group and congruency ($F_{2,22} = 4.43$, $p < 0.05$). Where data did not meet parametric assumptions Mann-Whitney U tests were completed on between group comparisons. There were no significant differences between the groups in the congruent condition. However, the comparison group was more accurate than the ASC group in the neutral ($Z = 3.90$, $n = 25$, $p < 0.001$) and incongruent conditions ($Z = 3.77$, $n = 25$, $p < 0.001$) (see Figure 1 and Table 1). The comparison group was significantly more accurate on the “mmms” task ($Z = 2.74$, $n = 25$, $p < 0.01$). On the faces task, the comparison group was also more accurate at identifying emotion from the face ($t = 4.197$; $df = 23$, $p < 0.001$).

The difference between the ASC group and the comparison group in the incongruent and neutral conditions and the lack thereof in the congruent condition indicate that the participants with ASC were generally relying more on the semantics of the sentence in identifying the emotions in the stimulus sentences. If this was the case, we would also expect their errors in the

incongruent trials to tend towards the emotion represented by the sentence semantics (which did not match with the emotion encoded in the voice). This was indeed the case. In the incongruent trials, persons with ASC selected a semantically-matching emotion significantly more frequently than persons from the comparison group (ASC: mean = 0.51, SD = 0.23; Control: mean = 0.28, SD = 0.12; $t = 3.297$, $df = 23$, $p < 0.01$).

In order to assess whether performance on the various tests was related, correlations were taken between the voice emotion recognition task and the facial emotion task, as well as the Millhill (Table 2). The faces task was correlated with the incongruent and neutral conditions of the sentence-based task, but not with the “mmms” task. None of the tasks were significantly correlated with performance on the Millhill vocabulary test.

Discussion

This study reports on a new test of vocal emotion, and tested whether individuals with ASC showed different degrees of divergence from typically developed individuals in interpreting emotions from the voice. We predicted that individuals with ASC would identify emotions at a similar level of performance to a typically developed comparison group when the intended emotion in the voice was also discernable from the semantic content of the sentence. Indeed identification of emotion in read sentences did not differ between the ASC group and the comparison group when the emotion in the voice and the meaning of the sentence were congruent. However, as predicted, identification was significantly poorer in persons with ASC for the trials when the sentence meaning and emotion in the voice were incongruent, when the meaning of the sentence was neutral, and for the trials when there was no lexical or semantic information (the “mmms”).

Second, we predicted that difficulties in interpreting emotions from voice and faces would be closely related in individuals with ASC, since both are subjected to a single cause in general cognition rather than modality-dependent problems in cue processing. There were significant correlations between emotion recognition from voice and from faces although the results must be treated with caution as the sample size is small. In addition, the correlation between ‘mmms’ and faces was not statistically significant. This may be due to the nature of the task, and that in general typically developing individuals found this task more difficult, with much lower accuracy.

There are a few important implications to be drawn from the results of the voice emotion recognition task, in which the ASC group, who otherwise found the task difficult, did not differ from the comparison group when there was matching information between the prosody and the semantics of the sentences. Indeed, the participants with ASC were the least accurate on the sentence task where the emotion in the voice and meaning of the sentence were incongruent, showing a much larger drop in accuracy than the control participants. In real-life exchanges we would expect vocal emotion to be congruent with the semantic content of an utterance, and when this is not the case that the message would be judged by the vocal emotion rather than the message content (Mehrabian and Wiener, 1967). An exception to congruent vocal emotion and semantic content are irony and sarcasm, where this congruency is flouted in order to give rise to a non-literal interpretation of the utterance. The current study thus suggests that the impairment in understanding irony in ASC (Wang et al., 2006) may be due to a difficulty using the vocal information to over-ride the semantics of an utterance. In this regard, it is also interesting to note that persons with ASC are often anecdotally reported to have a preference for communicating via email rather than in person.

The results of our study are consistent with the findings from Grossman et al. (2000) and Lindner and Rosén (2006), who also found ASC individuals' tendency to rely on semantic information in decoding emotion. When no semantic information was given, the individuals with ASC had more difficulty in identifying the emotion in the voice. In addition, when the semantic information was conflicting with the prosodic information (in the incongruent trials) individuals with ASC selected a semantically-matching emotion significantly more than persons from the comparison group. Individuals with ASC may utilise a range of strategies in order to understand affect in others, and may need to decode the information in a different way to typically developed individuals who tend to process emotional information in a more 'automatic' manner, using facial and prosodic cues. Whether these strategies mean that the individual understands what it is for another to have an emotion is beyond the scope of this study.

The participants in the current study and those in Grossman et al.'s (2000) and Lindner and Rosén's (2006) were all high functioning. Grossman et al. (2000) only included individuals with AS and those whose Full scale IQ was greater than 80 and verbal IQ greater than 90 on the Wechsler Intelligence Scale for Children, Third Edition (Wechsler, 1992). The current study only included those with High Functioning Autism or those with Asperger Syndrome. It is likely that the strategy of using verbal information rather than prosody or faces may not apply in groups whose IQ is lower or whose verbal skills are not as developed.

This study has a number of further limitations. It is a very small study, and how much these findings can be generalised to the ASC population as a whole is unknown. Indeed, as discussed, the findings may only be applicable to high functioning groups. Within that caveat, there are reasons to believe that our participants constitute a representative sample of the ASC population. Apart from the fact that all of the clinical participants were identified with high-

functioning autism or Asperger Syndrome (according to DSM criteria), the outcomes are consistent with other studies which assess emotional processing (Balconi and Carrera, 2007, Dyck et al., 2001, Humphreys et al., 2007, Peppé et al., 2007).

In conclusion, our study shows that despite difficulties shown in interpreting emotions from voice and faces, individuals with ASC can use semantic strategies to identify emotions. There is a shared mechanism behind problems in recognizing emotions in other individuals regardless of the modality of the information (acoustic-prosodic versus visual-facial). Although it remains to be tested whether such difficulties may be related to their comprehension of others' intentions, they are consistent with a model of ASC that places the locus of the deficit in the ability to impute emotional states in others.

References

- BALCONI, M. & CARRERA, A. 2007. Emotional representation in facial expression and script: A comparison between normal and autistic children. *Research in Developmental Disabilities*, 28, 409-422.
- BARON-COHEN, S., LESLIE, A. M. & FRITH, U. 1985. Does the autistic child have a 'theory of mind'? *Cognition*, 21, 37-46.
- BARON-COHEN, S., WHEELWRIGHT, S., HILL, J., RASTE, Y. & PLUMB, I. 2001. The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 42, 241-251.
- BOUCHER, J., LEWIS, V. & COLLIS, G. 1998. Familiar face and voice matching and recognition in children with autism. *Journal of Child Psychology and Psychiatry*, 39, 171-181.
- BUITELAAR, J. K. & VAN DER WEES, M. 1997. Are deficits in the decoding of affective cues and in mentalizing abilities independent? *Journal of Autism & Developmental Disorders*, 27, 539-56.
- CAPPS, L., YIRMIYA, N. & SIGMAN, M. 1992. Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 33, 1169-82.
- DYCK, M., FERGUSON, K. & SHOCHET, I. 2001. Do autism spectrum disorders differ from each other and from non-spectrum disorders on emotion recognition tests? *European Child & Adolescent Psychiatry*, 10, 105-116.
- EKMAN, P. 1993. Facial expression and emotion. *American Psychologist*, 48, 384-92.

- GILLBERG, C. 2002. *A guide to Asperger syndrome*, Cambridge, Cambridge University press.
- GOLAN, O., BARON-COHEN, S. & HILL, J. 2006. The Cambridge Mindreading (CAM) Face-Voice Battery: Testing Complex Emotion Recognition in Adults with and without Asperger Syndrome. *Journal of Autism and Developmental Disorders*, 36, 169-183.
- GOLAN, O., BARON-COHEN, S., HILL, J. J., RUTHERFORD, M. D., GOLAN, O., BARON-COHEN, S. & HILL, J. J. 2007. The 'Reading the Mind in the Voice' test-revised: a study of complex emotion recognition in adults with and without autism spectrum conditions. *Journal of Autism & Developmental Disorders*, 37, 1096-106.
- GROSSMAN, J. B., KLIN, A., CARTER, A. S. & VOLKMAR, F. R. 2000 Verbal bias in recognition of facial emotions in children with Asperger syndrome. *Journal Of Child Psychology And Psychiatry, And Allied Disciplines*, 41, 369-379.
- HOBSON, R. 2007. Communicative depth: Soundings from developmental psychopathology. *Infant Behavior & Development*, 30, 267-277.
- HOBSON, R., OUSTON, J. & LEE, A. 1989. Naming emotion in faces and voices: Abilities and disabilities in autism and mental retardation. *British Journal of Developmental Psychology*, 7, 237-250.
- HUMPHREYS, K., MINSHEW, N., LEONARD, G. L. & BEHRMANNA, M. 2007. A fine-grained analysis of facial expression processing in high-functioning adults with autism. *Neuropsychologia*, 45, 685-695.

- KLEINMAN, J., MARCIANO, P. L. & AULT, R. L. 2001. Advanced theory of mind in high-functioning adults with autism. *Journal of Autism & Developmental Disorders*, 31, 29-36.
- LINDNER, J. L. & ROSÉN, L. A. 2006. Decoding of emotion through facial expression, prosody and verbal content in children and adolescents with Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 36, 769-777.
- LOVELAND, K. A., TUNALI-KOTOSKI, B., CHEN, R., BRELSFORD, K. A. & ET AL. 1995. Intermodal perception of affect in persons with autism or Down syndrome. *Development and Psychopathology*, 7, 409-418.
- LYONS, M. J., BUDYNEK, J. & AKAMATSU, S. 1999. Automatic classification of single facial images. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 21, 1357-1362.
- MEHRABIAN, A. & WIENER, M. 1967. Decoding of Inconsistent Communications. *Journal of Personality and Social Psychology*, 6, 109-114.
- OZONOFF, S., PENNINGTON, B. F. & ROGERS, S. J. 1991. Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 32, 1081-1105.
- PAUL, R., AUGUSTYN, A., KLIN, A. & VOLKMAR, F. R. 2005. Perception and Production of Prosody by Speakers with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 35, 205-220.
- PEPPÉ, S., MCCANN, J., GIBBON, F., O'HARE, A., RUTHERFORD, M., PEPPE, S., MCCANN, J., GIBBON, F., O'HARE, A. & RUTHERFORD, M. 2007.

- Receptive and expressive prosodic ability in children with high-functioning autism. *Journal of Speech Language & Hearing Research*, 50, 1015-28.
- RAVEN, J. C., RAVEN, J. E. & COURT, J. H. 1998. Section 4: Advanced progressive matrices. *Manual for Raven's progressive matrices and vocabulary scales*. Oxford.
- RUTHERFORD, M. D., BARON-COHEN, S., WHEELWRIGHT, S., BARON-COHEN, S. & WHEELWRIGHT, S. 2002. Reading the mind in the voice: a study with normal adults and adults with Asperger syndrome and high functioning autism. *Journal of Autism & Developmental Disorders*, 32, 189-94.
- VAN LANCKER, D. R., CORNELIUS, C. & KREIMAN, J. 1989. Recognition of emotional-prosodic meanings in speech by autistic, schizophrenic, and normal children. *Developmental Neuropsychology*, 5, 207-226.
- WANG, A. T., LEE, S. S., SIGMAN, M. & DAPRETTO, M. 2006. Neural basis of irony comprehension in children with autism: the role of prosody and context. *Brain*, 129, 932-43.

Table 1: Performance on voice, faces, and verbal ability tasks by group

| | ASC Group | | Comparison Group | |
|----------------------|---------------|-----------|------------------|-----------|
| | Mean (SD) | Range | Mean (SD) | Range |
| Accuracy Congruent | 0.68 (0.17) | 0.38-0.90 | 0.74 (0.10) | 0.55-0.95 |
| Emotion | | | | |
| Accuracy Incongruent | 0.18 (0.12)** | 0.03-0.33 | 0.38 (0.08) | 0.25-0.50 |
| Emotion | | | | |
| Accuracy Neutral | 0.31 (0.11)** | 0.15-0.50 | 0.53 (0.07) | 0.43-0.65 |
| Emotion | | | | |
| ‘mmms’ accuracy | 0.33 (0.07)* | 0.15-0.50 | 0.42 (0.09) | 0.23-0.59 |
| Faces accuracy | 0.55 (0.08)* | 0.40-0.67 | 0.68 (0.07) | 0.52-0.75 |
| Millhill (verbal IQ) | 14.9 (6.2) | 6-25 | 18.1 (4.0) | 8-23 |
| Age | 27.2 (7.5) | 17-39 | 26.4 (5.6) | 21-37 |

Between group comparisons ** $p < 0.001$ * $p < 0.005$

Table 2: Correlations between the Emotional Recognition Measures and the Millhill (Verbal IQ)

| | Faces | Millhill |
|-------------|--------|----------|
| Congruent | 0.25 | -0.15 |
| Incongruent | 0.55** | 0.39 |
| Neutral | 0.44* | 0.13 |
| ‘mmms’ | 0.18 | 0.11 |
| Faces | - | 0.27 |

** $p < 0.01$; * $p < 0.05$

Figure 1: Mean accuracy on the vocal emotion task for the congruent, incongruent and neutral conditions by group.

